Inflation uncertainty and monetary policy in the Eurozone – Evidence from the ECB Survey of Professional Forecasters

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ECB: “Eurozone inflation expectations are \textit{WELL ANCHORED}”.

Annual inflation rate (red line) and average SPF forecast
Forecast horizon of 4 quarters \((h = 4)\): dotted black line,
Forecast horizon of 8 quarters \((h = 8)\): dashed line,
Forecast horizon of 20 quarters \((h = 20)\): solid line.
ECB: “Eurozone inflation expectations are WELL ANCHORED”. However, increase in std. dev. of aggregate density forecast since ∼2008

Forecast horizon of 4 quarters ($h = 4$): dotted black line,
Forecast horizon of 8 quarters ($h = 8$): dashed line,
Forecast horizon of 20 quarters ($h = 20$): solid line.
This talk

- In contrast to inflation expectations, IU has not returned to its pre-crisis level

- Main questions of interest:
  1. What determines aggregate inflation uncertainty?
  2. How can differences in forecasters’ individual IU be explained?

- Discuss ways to measure IU by survey data

- Highlight various potential drivers of individual and aggregate IU:
  1. central bank policy, macroeconomic factors and policy uncertainty
  2. characteristics of survey cross-section: group-specific forecasting success, reversal to aggregate IU
Data

- Forecast data from Survey of Professional Forecasters (SPF)
  - Quarterly data \( t = 1, \ldots, T \) for 1999Q1-2013Q2 \( \rightarrow T = 58 \)
  - Individual forecast data from a panel of 75 active forecasters on HICP inflation
  - Forecast horizons of fixed length: \( h = \{4, 8, 20\} \) quarters, \( h = 20 \) refers to entire year
  - Forecasters assign probabilities to \( b = 1, \ldots, B \) “bins”
  - Lower bound = -0.5 for 1999Q1-2009Q1, = -2.5 for 2009Q2-2009Q4 and = -1.5 for 2010Q1-2013Q2
  - Upper bound = 4.5 for 2000Q4 as well as 2008Q3-2013Q2 and = 4.0 else
  - For \( h = 20 \), sample is shorter: 2001Q1 to 2013Q2 \( \rightarrow T = 50 \)
  - Missing values are numerous. \( \sim 60 \) responses per survey round
Measuring $IU$ based on SPF data

- Beta distribution is fitted both to individually reported probabilities and their cross-sectional mean

→ Obtain individual and aggregate inflation uncertainty as standard deviation of respective beta-densities

- Individual inflation uncertainty is denoted $iu_{i,t+h|t}$

- Aggregate inflation uncertainty is denoted $IU_{t+h|t}$
Case 1: 1 bin is used
- probability density function takes form of isosceles triangle
- base length = bin width
- height = $2 \times 100 \times$ base length

Case 2: 2 bins
- Suppose a forecaster assigns probability $p$ and $1 - p$ to the intervals $[y\%, (y + 1)\%)$ and $((y + 1)\%, (y + 2)\%]$. Let $t = \sqrt{p/2}/(1 - \sqrt{p/2})$.
- pdf given by isosceles triangle with endpoints $(y + 1 - t)\%$ and $(y + 2)\%$
- height = $200/(t + 1)$
Case 3: 3 or more bins are used. Estimate parameters $\alpha, \beta$ of generalized beta distribution by NLS:

$$\alpha, \beta = \arg \min_{\alpha_0, \beta_0} \sum_{b=1}^{B} \left[ \text{Beta}(t_b; \alpha_0, \beta_0, lb, ub) - F(t_b) \right]^2.$$  \hspace{1cm} (1)

where

$$\text{Beta}(t; \alpha, \beta, lb, ub) = \begin{cases} 0 & \text{if } t \leq lb \\ \frac{1}{B(\alpha, \beta)} \int_{lb}^{t} \frac{(x-lb)^{\alpha-1}(ub-x)^{\beta-1}}{(ub-lb)^{\alpha+\beta-1}} \, dx & \text{if } lb \leq t < ub \\ 1 & \text{if } t > ub \end{cases}$$
SPF Data

Figure: Individual forecasters panel
Data

Inflation expectations, $h = 1$
Estimates of $IU^\bullet_{t+h|t}$

Histogram-based (Empirical distr.) vs. Engelberg (Beta distr.) approach:

$IU^\bullet_{t+4|t}$

$IU^\bullet_{t+20|t}$
Aggregate Variance vs Disagreement

A frequently used proxy for $IU$ is the so-called “Disagreement” statistic

$$s_{t+h|t} = \sum_{i=1}^{N} (\hat{\pi}_{i,t+h|t} - \bar{\hat{\pi}}_{t+h|t})^2. \quad (2)$$

where $i = 1, ..., N$ refers to forecasters in the survey

- Aggregate variance can be decomposed as:

$$\left(IU_{t+h|t}^{\bullet}\right)^2 = \frac{1}{N} \sum_{i=1}^{N} iu_{i,t+h|t}^2 + s_{t+h|t}. \quad (3)$$

- $s_{t+h|t}$ is one component of aggregate variance
Aggregate Variance vs Disagreement

\[
(IU^*_{t+h|t})^2 - s_{t+h|t}
\]

Empirical (Histogram)

Forecast horizon of 4 quarters \((h = 4)\): dotted line,
Forecast horizon of 8 quarters \((h = 8)\): dashed line,
Forecast horizon of 20 quarters \((h = 20)\): solid line.

Beta
What determines $IU$?

Do observable quantities help to explain

- $IU^\bullet_{t+h|t}$ (aggregate) ?
- $iu_{i,t+h|t}$ (individual-specific) ?

Potential triggers:

1. macroeconomic quantities
2. indicators of central bank policy
3. indicators of policy uncertainty
Explanatory variables

- $OU_{t+h|t}^*$: Output (GDP) growth uncertainty, derived as $IU_{t+h|t}^*$
- $\pi$: Eurozone inflation rate
  - year-on-year growth rate of HICP: $\pi_t = 100 \times \ln(HICP_t/HICP_{t-4})$
- $y_t$: Real, annual GDP growth rate in Eurozone: $\ln(GDP_t/GDP_{t-4})$
- $SD(E)$: World equity price volatility
  - quarterly volatility of the MSCI World Equity Index (captures the evolution of over 6000 stock prices for 23 industrial countries in US dollars)

$$SD_t(E) = 100 \times \sqrt{\sum_{d \in t} r_{d,t}^2}$$

where $r_{d,t} = \log(P_{d,t}/P_{d-1,t})$ is the return on day $d$ in quarter $t$
Explanatory variables – Policy-related

- **Assets**: ECB assets
  - based on total loans for the euro area in trillions of euros (changing composition, unspecified counterpart sector)
- **PolU**: Bloom et al. (2012) Policy Uncertainty index
  - newspaper coverage of policy-related economic uncertainty (weight 0.5)
  - forecaster disagreement about federal government budget balances (weight 0.25)
  - forecaster disagreement about consumer prices (weight 0.25) → discarded
Explanatory variables – Policy-related

- **TD**: Taylor rule deviations

  \[ TD_t = i_t - i^*_t = i_t - r - 1.5(\pi_t - \pi^*_t) - 0.5 \tilde{y}_t, \]

  where \( i \) is the actual interest rate, \( i^* \) is the Taylor rule interest rate and
  \( \tilde{y}_t = 100 \times (gdp_t - gdp_{t, HP}) \) denotes the output gap, where \( gdp_t = \ln(GDP_t) \).

  Moreover, \( gdp_{t, HP} \) is HP-filtered trend

  - \( TD > 0 \) indicates “restrictive” monetary policy
  - \( TD < 0 \) indicates “expansionary” monetary policy

- **MPC**: KOF Monetary Policy Communicator

  - translates the ECB president’s statements on price stability during monthly press conferences into numerical values (\( MPC \in [-1, 1] \))
  - higher values depending on how often the term “inflation risk” is mentioned in ECB communication
Policy uncertainty ($PoliU$)  

$SD(E)$

$TD$  

$Assets$
## Determinants of aggregate $IU^*_{t+h|t}$

|                          | $IU^*_{t+4|t}$ | $IU^*_{t+8|t}$ | $IU^*_{t+20|t}$ |
|--------------------------|----------------|----------------|-----------------|
| $IU^*_{t+4−1|t−1}$      | 0.29           | −0.08          | 0.024           |
|                          | (1.62)         | (0.54)         | (0.14)          |
| $IU^*_{t+8−1|t−1}$      | **0.51** *     | **0.67** *     | 0.411           |
|                          | (1.97)         | (3.19)         | (1.60)          |
| $IU^*_{t+20−1|t−1}$     | −**0.44** *    | −0.11          | 0.132           |
|                          | (−2.08)        | (−0.68)        | (0.63)          |
| $OU_{t+h−1|t−1}$        | **0.23** *     | −0.07          | −0.058          |
|                          | (2.01)         | (−0.72)        | (−0.51)         |
| $\pi_{t−1}$             | 0.01           | −0.01          | −0.015          |
|                          | (0.43)         | (−1.61)        | (−1.21)         |
| $y_{t−1}$               | −0.07          | −0.38          | −0.183          |
|                          | (−0.16)        | (−1.09)        | (−0.43)         |
| $SD_{t−1}(E)$           | **0.71** *     | **0.46** *     | −0.011          |
|                          | (4.76)         | (3.87)         | (−0.07)         |
| $Assets_{t−1}$          | 0.01           | **0.01** *     | 0.000           |
|                          | (1.41)         | (2.21)         | (0.50)          |
| $PolU_{t−1}$            | 0.01           | 0.01           | 0.028           |
|                          | (0.17)         | (0.26)         | (0.81)          |
| $TD_{t−1}$              | −0.01          | −0.01          | −**0.017** *    |
|                          | (−1.58)        | (−1.46)        | (−2.18)         |

| $T$                     | 49             | 49             | 49              |

BG-LM (4) p-val.        0.41  0.02  0.07
BG-LM (8) p-val.        0.15  0.05  0.28
Determinants of individual-specific $i\mu_{i,t+4|t}$

Figure: Individual forecasters panel
Determinants of individual-specific $i u_{i,t+4|t}$

**Figure:** Individual forecasters panel (only include forecasters with more than 20 consecutive SPF participations)
Determinants of individual-specific $i\mu_{i,t+4|t}$

Recall: We analyze data from experts. (Survey of Professional Forecasters)!

- Exploit cross sectional variation
- Idea: guidance from most successful forecasters among SPF-experts on selection of $iU$-indicators
- Criterion: absolute prediction error
  $$a_{i,t+h|t} = |\hat{e}_{i,t+h|t}| = |\pi_{t+h} - \hat{\pi}_{i,t+h|t}|$$

- 2 ways of classifying forecasters:
  1. **Unconditional outperformance**, holds for those of $i = 1, ..., N$ forecasters where
     $$a_i = \frac{1}{T} \sum_{t=1}^{T} a_{i,t+h|t} < \text{median}_i(a_i)$$
  2. **Conditional outperformance**: for each $t = 1, ..., T$, select forecasters satisfying
     $$a_{i,t+h|t} < \text{median}_i(a_{i,t+h|t})$$
Determinants of $iu_{i,t+4|t}$, FE regression

<table>
<thead>
<tr>
<th></th>
<th>full sample</th>
<th>Unconditional performance</th>
<th>Conditional performance</th>
</tr>
</thead>
<tbody>
<tr>
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<td>$a &lt; \text{median}$</td>
<td>$a \geq \text{median}$</td>
<td>$a &lt; \text{median}$</td>
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<tr>
<td><strong>constant</strong></td>
<td>0.73</td>
<td>0.55</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(1.67)</td>
<td>(0.75)</td>
<td>(1.93)</td>
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<tr>
<td>**$OU_{t+h-1</td>
<td>t-1}$**</td>
<td><strong>0.12</strong> *</td>
<td>0.08</td>
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<tr>
<td></td>
<td>(2.92)</td>
<td>(1.10)</td>
<td>(2.82)</td>
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<tr>
<td><strong>$\pi_{t-1}$</strong></td>
<td><strong>-0.03</strong> *</td>
<td><strong>-0.05</strong> *</td>
<td><strong>-0.02</strong> *</td>
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<tr>
<td></td>
<td>(-3.86)</td>
<td>(-2.14)</td>
<td>(-2.14)</td>
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<tr>
<td><strong>$y_{t-1}$</strong></td>
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<td>-0.25</td>
<td>-0.69</td>
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<td></td>
<td>(-1.00)</td>
<td>(-0.36)</td>
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<tr>
<td><strong>$SD(E)_{t-1}$</strong></td>
<td>0.20</td>
<td>0.25</td>
<td>0.17</td>
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<td></td>
<td>(1.68)</td>
<td>(1.23)</td>
<td>(1.14)</td>
</tr>
<tr>
<td><strong>$Assets_{t-1}$</strong></td>
<td><strong>0.02</strong> *</td>
<td><strong>0.03</strong> *</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(2.86)</td>
<td>(2.25)</td>
<td>(1.47)</td>
</tr>
<tr>
<td><strong>$PolU_{t-1}$</strong></td>
<td>0.05</td>
<td><strong>0.10</strong> *</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(1.77)</td>
<td>(2.05)</td>
<td>(0.73)</td>
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<tr>
<td><strong>$TD_{t-1}$</strong></td>
<td><strong>-0.03</strong> *</td>
<td><strong>-0.02</strong> *</td>
<td><strong>-0.03</strong> *</td>
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<tr>
<td></td>
<td>(-5.21)</td>
<td>(-2.52)</td>
<td>(-4.75)</td>
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<tr>
<td><strong>$MPC_{t-1}$</strong></td>
<td>0.03</td>
<td><strong>0.15</strong> *</td>
<td>-0.03</td>
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<tr>
<td></td>
<td>(1.12)</td>
<td>(2.58)</td>
<td>(-0.86)</td>
</tr>
<tr>
<td><strong>Cross-sections:</strong></td>
<td>24</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total no. of obs.:</strong></td>
<td>992</td>
<td>443</td>
<td>549</td>
</tr>
</tbody>
</table>
Relation between $i_{u_i,t+h|t}$ and $I_{U^\bullet_{t+h|t}}$

In contrast to forecasts for conditional mean of $\pi$, no ex-post comparison of forecast $i_{u_i,t+h|t}$ and realized value possible.

- Do forecasters consider “consensus” (=aggregate) $I_{U^\bullet_{t+h|t}}$ as benchmark?

- If so, is adjustment towards aggregate $I_{U^\bullet_{t+h|t}}$ related to observable quantities such as, e.g., (monetary) policy indicators?

- Model joint dynamics of individual uncertainty ($i_{u_i,t+h|t}$) and deviations from the aggregate ($I_{U^\bullet_{t+h|t}}$), i.e. $\tilde{i}_{u_i,t+h|t} = i_{u_i,t+h|t} - I_{U^\bullet_{t+h|t}}$.
\[ \tilde{i}u_{i,t+h|t} = iu_{i,t+h|t} - IU_{t+h|t} \]

\[ iu_{i,t+4|t} \]

\[ \tilde{i}u_{i,t+h|t} = \beta_1 + \beta_2 \tilde{i}u_{i,t+h|t} I(iu_{i,t+h|t} > 0) + \beta_3 \tilde{i}u_{i,t+h|t} I(iu_{i,t+h|t} < 0) + \epsilon_{i,t+h|t} \]

where \( I(\cdot) \) denotes the indicator function.
Relation between $i u_{i,t+h|t}$ and $\hat{U}_{t+h|t}$

Model joint dynamics of individual uncertainty ($i u_{i,t+h|t}$) and deviations from the aggregate ($\hat{U}_{t+h|t}$), i.e. $\tilde{i}u_{i,t+h|t} = i u_{i,t+h|t} - \hat{U}_{t+h|t}$

$$\tilde{i}u_{i,t+h|t} = \beta_{11} + \beta_{12} \tilde{i}u_{i,t+h-1|t-1} + \beta_{13} i u_{i,t+h-1|t-1} + \varepsilon_{i 1, t+h} \quad (4)$$

$$i u_{i,t+h|t} = \beta_{21} + \beta_{22} \tilde{i}u_{i,t+h-1|t-1} + \beta_{23} i u_{i,t+h-1|t-1} + \varepsilon_{i 2, t+h} \quad (5)$$

After estimating (4) and (5), obtain

$$\Delta \tilde{i}u_{i,t+h|t} = b_{11} + (1 - b_{12}) \tilde{i}u_{i,t+h-1|t-1} + b_{13} i u_{i,t+h-1|t-1} \quad (6)$$

$$\Delta i u_{i,t+h|t} = b_{21} + b_{22} \tilde{i}u_{i,t+h-1|t-1} + (1 - b_{23}) i u_{i,t+h-1|t-1} \quad (7)$$

where, e.g., $\Delta i u_{i,t+h|t} = i u_{i,t+h|t} - i u_{i,t+h-1|t-1}$.

→ Graphical display of joint dynamics of $i u_{i,t+h|t}$ and $\tilde{i}u_{i,t+h|t}$ based on (6) and (7)
\( iu_{i,t+h|t} \) and \( IU^*_{t+h|t} \): phase diagrams, \( h = 4 \)

Full sample (992 obs.)

\( a < \text{median (549 obs.)} \)

\( a \geq \text{median (443 obs.)} \)
$i_{t+h}^i$ and $lU_{t+h}^i$: phase diagrams, $h = 4$

$MPC \rightarrow IU_{t+4}^i$ (803 obs.)

$PolU \rightarrow IU_{t+4}^i$ (741 obs.)

$MPC \rightarrow IU_{t+4}^i$ (189 obs.)

$PolU \rightarrow IU_{t+4}^i$ (251 obs.)
$iu_{i,t+h|t}$ and $IU_{t+h|t}^*$: phase diagrams, $h = 4$

Full sample (992 obs.)

$TD^{France} \rightarrow IU_{t+4|t}^*$ (545 obs.)

$TD^{Germany} \rightarrow IU_{t+4|t}^*$ (605 obs.)

$TD^{Ireland} \rightarrow IU_{t+4|t}^*$ (371 obs.)
$iu_{i,t+h|t}$ and $IU^*_{t+h|t}$: phase diagrams, $h = 4$

$TD^{Italy} \rightarrow IU^*_{t+4|t}$ (638 obs.)

$TD^{Netherlands} \rightarrow IU^*_{t+4|t}$ (642 obs.)

$TD^{Portugal} \rightarrow IU^*_{t+4|t}$ (301 obs.)

$TD^{Spain} \rightarrow IU^*_{t+4|t}$ (458 obs.)
Conclusion

- Analyzing aggregate IU, we find
  - Spillovers from output uncertainty (short horizon)
  - Effect of fluctuations on worldwide equity markets (short horizon)
  - Positive relation to increases in ECB balance sheet (medium horizon)
  - Increases in IU during expansionary monetary policy – Taylor rule (medium horizon)

- Individual \( IU \):
  - Distinguish determinants of \( iu_{i,t+h|t} \) for more/less successful forecasters
  - \( iu_{i,t+h|t} \) of successful forecasters reacts to ECB balance sheet expansions, central bank communication, policy uncertainty

- Relation between aggregate and individual IU:
  - Positive deviations of individual IU from aggregate IU persists if forecasters’ IU related to ECB communication
  - Differences in individual IU related to idiosyncratic characteristics of Eurozone member states